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Natural and Induced Dormancy in Sorghum vulgare Pers

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NATURAL AND INDUCED DORMANCY IN SORGHUM VULGARE PERS.

BY

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This thesis is approved as a creditable, independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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TABLE OF CONTENTS

	Page
INTRODUCTION	1
REVIEW OF LITERATURE	3
MATERIALS AND METHODS	13
EXPERIMENTAL RESULTS	20
Forage Sorghum Germinations	20
Treatment of Dormant Forage Sorghums	21
Grain Sorghum Germinations	39
DISCUSSION	48
SUMMARY	54
LITERATURE CITED	56

LIST OF TABLES

Table		Page
1.	Percent germination of the forage sorghum Rancher collected at the Menno and Highmore stations in 1957 showing dates harvested and tested, percent moisture when harvested, and methods of handling when harvested with each method tested with and without a prechill	22
2.	Percent germination of the forage sorghum 39-30-S collected at the Menno and Highmore stations in 1957 showing dates harvested and tested, percent moisture when harvested and methods of handling when harvested, with each method tested with and without a prechill	23
3.	Percent germination of the forage sorghum Rancher collected at the Brookings and Watertown stations in 1958, 1959, and 1960 showing dates harvested and tested, percent moisture when harvested, and methods of handling when harvested with each method tested with and without a prechill	24
4.	Percent germination of the forage sorghum 39-30-S collected at the Brookings and Watertown stations in 1958, 1959, and 1960 showing dates harvested and tested, percent moisture when harvested and methods of handling when harvested with each method tested with and without a prechill	25
5.	Total germination of Rancher and 39-30-S forage sorghums harvested at the Brookings and Watertown stations in 1958. Ungerminated seeds were given an additional five days in the germinator. After the ten day germination period glumes were removed from seed on one blotter of each 2x100 seed replicate; glumes were left intact on the other	27
6.	Percent germination of the forage sorghums, Rancher and 39-30-S, harvested at the Brookings station in 1959. Dormant seed from the first germination test was left on blotters and given an additional 30 days in an alternating 20-30°C germinator with germination counts taken at five day intervals	28

Table Page

7. November 12 germination of dormant Rancher and 39-30-S forage sorghums harvested at the Brookings and Watertown stations September 15, October 6, and October 28, 1958, after pretreatments of 40°C oven four days, 50°C oven four days, submerged in 75°C and 70°C water baths four minutes, and a three day presoak in tap water 29

8. Percent field emergence at the Brookings station July 5, 1958, of Norghum, Rancher, 39-30-S, and Reliance sorghums harvested at the Menno and Highmore stations in 1957 using treated and untreated subsamples 31

9. Percent germination of dormant Rancher and 39-30-S forage sorghums harvested at the Brookings station in 1959 and 1960 and germinated on blotters soaked in tap water after 24 hour pretreatments of (1) soaking the seeds in KNO_3 solutions and (2) placing the seeds on blotters soaked in KNO_3 solutions of 0.1, 0.2, 0.4, 1.0, 2.0, and 4.0 percent 32

10. Analysis of variance of germination percentages of dormant Rancher and 39-30-S forage sorghums harvested in 1959 and 1960, and germinated on blotters soaked in tap water after 24 hour pretreatments of (1) soaking the seeds in KNO_3 solutions and (2) placing the seeds on blotters soaked in KNO_3 solutions of 0.1, 0.2, 0.4, 1.0, 2.0, and 4.0 percent 33

11. Percent germination of the 1959 harvest of Rancher and 39-30-S forage sorghums tested on October 14 and the 1960 harvest tested December 29 on blotters soaked in solutions of 1000, 500, 250, 125, 62.5, 31.75, 15.88, and 7.94 milligrams per liter of gibberellic acid 34

12. Analysis of variance of the mean germination percentages of dormant Rancher and 39-30-S forage sorghums harvested at the Brookings station in 1959 and 1960 and germinated on blotters soaked in 1000, 500, 250, 125, 62.5, 31.95, 15.88, and 7.94 milligrams per liter of gibberellic acid 36

13. November 4, 1959, germination of Rancher and 39-30-S forage sorghums harvested at the Brookings station October 27, 1959, and germinated on blotters soaked in solutions of 0.1, 0.2, 0.4, 1.0, 2.0, and 4.0 percent KNO_3 36

Table Page

14. November 24, 1959, germination and analysis of variance of Rancher and 39-30-S forage sorghums harvested at the Brookings station November 20, 1959, after pretreatments where glumes were pricked and a chip removed from the side of the seed coat adjacent to the germ, a chip was removed from the tip of seed, glumes were removed, glumes were removed and seed coat chipped at tip of seed, and glumes were removed and seed coat chipped adjacent to the germ 37

15. Percent germination of Rancher and 39-30-S forage sorghum harvested at the Brookings station in 1959 and tested October 23 both with and without a five day prechill at constant 30°C, constant 20°C, alternating 15-30°C, alternating 20-30°C and 0.2 percent KNO_3 38

16. Percent germination of Rancher and 39-30-S forage sorghums harvested at the Brookings station in 1959 and 1960 and germinated at an alternating temperature of 30-45°C . . . 40

17. Analysis of variance of the mean germination percentages of dormant Rancher and 39-30-S forage sorghums harvested at the Brookings station in 1959 and 1960 and germinated at an alternating temperature of 30-45°C 40

18. Respiration of dormant and nondormant samples of Rancher forage sorghum harvested at the Brookings station in 1960 using samples that had been in the crop dryer. Respiration is given as milligrams of CO_2 evolved and was checked with and without the outer glumes removed 41

19. Percent germination of the grain sorghum Reliance collected at the Menno and Highmore stations in 1957 showing dates harvested and tested, percent moisture when harvested, and methods of handling when harvested with each method tested with and without a prechill 42

20. Percent germination of the grain sorghum Norghum collected at the Menno and Highmore stations in 1957 showing dates harvested and tested, percent moisture when harvested, and methods of handling when harvested with each method tested with and without a prechill 43

Table | Page

21. Percent germination of the grain sorghums, Reliance and Norghum, harvested at the Brookings and Watertown stations in 1958 showing dates harvested and tested, percent moisture when harvested, and methods of handling when harvested with each method tested with and without a prechill 44

22. Percent germination of the grain sorghum Dual collected at the Brookings and Watertown stations in 1958 showing dates harvested and tested, percent moisture when harvested, and methods of handling when harvested, with each method tested with and without a prechill 45

23. Percent germination of Norghum, Reliance, and RS 501 grain sorghums harvested at the Brookings station in 1959 showing dates harvested and tested, percent moisture when harvested, and methods of handling when harvested with each method tested with and without a prechill 46

INTRODUCTION

Plant breeders interested in hybrid sorghum in the past few years have initiated intensive improvement programs whereby two or three generations of breeding stock may be grown each year. To accomplish this, seed must be harvested as early as is possible, dried immediately, and planted within a few weeks after harvest.

During routine testing of these freshly harvested and dried seeds, many samples were found which did not give satisfactory germination results. The low germinating samples were checked with a triphenyl tetrazolium chloride solution to determine their potential viability. The tetrazolium test indicated the seed was 100 percent viable. This evidence pointed to the fact that these samples were in a temporary state of dormancy. The same samples tested a few months after harvest gave satisfactory germination.

Similar difficulty has been encountered at the South Dakota Seed Laboratory. The Agronomy Seed Laboratory tests all samples for the Seed Certification Service. These tests determine whether or not the samples submitted for certification meet the certification standards for purity and germination.

The minimum certification standard for germination of Sorghum vulgare Pers. seed is 80 percent (2). The Agronomy Seed Laboratory obtained many germination percentages below this standard during routine testing of sorghum samples for the Certification Service. This was especially evident for the forage sorghums. Further testing with a tetrazolium salt solution showed the samples had a much higher

potential germination. Dry storage of these same samples in the laboratory for three to four months gave germinations comparable to the tetrazolium results. A special treatment for fresh and dormant seed, recommended by the Association of Official Seed Analysts in the publication Rules for Testing Seeds (1), had no beneficial effect on the germination of these dormant lots of seed.

This study was undertaken to determine if dormancy is present in the grain and forage sorghums. It was also desired that a reliable method for breaking dormancy could be devised for use in testing dormant samples of sorghum at the Agronomy Seed Laboratory.

REVIEW OF LITERATURE

Dormancy or delayed germination has caused trouble at some time or other in practically all agricultural crop seeds. However, different kinds of seeds vary considerably in the degree and type of dormancy they exhibit.

Crocker (10) gives a good review of the types of dormancy and how they may be overcome with proper treatment. Dormancy in seeds of wild plants is advantageous from the standpoint of perpetuation of the species. A period of low temperature is required by many kinds of seeds before they will germinate. Hard, impermeable seed coats prevent germination in many seeds. In others, an impervious membrane restricts gas exchange. Light has been shown to be beneficial in breaking dormancy in some seeds, but will retard or cause secondary dormancy in others. Many chemicals and gases such as NH_3, Cl_2, HCN, HS, and SO_2 will also inhibit germination. If the concentration is too high, however, some of these gases became toxic and reduced germination resulted. Naturally occurring chemical inhibitors in the seed coat, cotyledons, or embryo also cause dormancy in many seeds.

A considerable number of workers have shown that many kinds of agricultural seeds do not germinate readily immediately following harvest. Whitcomb (33) working with the cereal grains, winter and spring wheat, barley, and oats studied the effects of maturity and harvest dates, field curing before threshing, temperature variation in the laboratory germinator, aging the seed in the laboratory, and field germination. Results of this study are in agreement with the general

belief of seed analysts that cereal grains have a dormant period time with low initial germination. Aging in the laboratory exhibited the most marked effect of any treatment in decreasing dormancy. However, laboratory germinations comparable to field germinations were obtained by exposing the seeds to a low temperature of 5°C for six days and then germinating them in a 20-30°C alternating germinator. His results confirm the contentions held by farmers that plantings of newly harvested grains, although dormant in laboratory tests, produce good field stands.

Kisselbach and Ratcliff (19), in a detailed investigation on seed corn, found that severe freezing of immature corn greatly reduced the viability of the seed. Planting dates were varied to allow harvest of different stages of maturity at the same time. Each sample was subdivided and part was dried artificially; the other was subjected to various freezing temperatures. It was stored 4-5 months and then germination tests were made. From this they concluded that seed corn maturing in the field became increasingly more cold resistant as the moisture content decreased and that the viability of corn having 15-20 percent moisture would not be injured by ordinary fall temperatures.

Crocker and Barton (11) suggested that the mechanism inhibiting the normal germination of freshly harvested immature corn operates in the scutellum of the embryo, since germinating corn kernels require 35 percent moisture in the whole grain but 60 percent in the embryo.

Delouche and Bass (13), working with western wheatgrass, demonstrated that germination decreases as light is increased and that light has a residual inhibiting effect that is not entirely overcome when

samples are given a long dark treatment after exposure. They found that four to eight days darkness at the beginning of the germination period gave germinations equivalent to those in continuous darkness for the whole period.

It is the opinion of Delouche and Bass (13) that the effect of light is directly on the embryo and that the inhibition of germination by light is apparently one of the mechanisms of dormancy in western wheatgrass. They assume this to be the case since seeds treated with ethylene chlorohydrin counteracted the inhibiting effect of light on germination thus showing that the chemical acts directly on the embryo, aside from any effect it may have on intervening membranes.

These authors' results are in close agreement with the general hypothesis that at least one of the mechanisms of dormancy operating in grass seeds is the restriction of gas exchange (O_2CO_2) by the seed membranes. Rupturing of the seed membranes gave an increased germination percentage over the check of intact seeds under both light and dark treatments, but there was still some inhibition by light for the exposed embryo treatment.

Bass (7) found that removal of western wheatgrass lemmas and puncturing the membrane over the embryo gave a much more complete germination than either the light or dark tests previously recommended by the Association of Official Seed Analysts. This method gave comparable results to the tetrazolium tests on the same samples of seed.

It was the contention of Laude (21) that seed coats of California oatgrass hindered germination by mechanical restraint and restriction of gas exchange but that they did not hinder the absorption of water. Treating the seed with concentrated sulfuric acid or chipping the seed coat with a scalpel gave much higher germination than the check.

Light sensitivity suggests the presence of a pigment. Borthwick, Hendricks, Parker, Toole and Toole (8) produced evidence of two reversible photoreaction pigments that were apparently involved with other reactants in controlling seed germination. Germination of some seeds is promoted by light while in others it is inhibited. This is a result of the integrated effect of the photoreaction and suggests that the amount of the pigments and reactants vary among seeds.

Highland bentgrass exhibits marked dormancy in laboratory germination tests, but in field plantings dormancy is no problem. Pierpont and Jensen (25) were able to overcome this dormancy by placing the seed 3 1/2cm from a source of infra red light for 30 seconds. Best results were obtained when seeds were planted on blotters moistened with 0.2 percent KNO_3 and the nondormant seeds allowed to reach sufficient growth for seedling evaluation. The normal seedlings were then removed before treatment with the infra red lamp. It was also necessary to remove swollen seeds and regulate the moisture of the substratum before treatment. If this was not done, the swollen seeds were often injured. If the moisture of the substratum was too dry, no stimulation resulted; if it was too wet, injury to the seeds was evident.

Primary dormancy of Plantago major and rugellii was broken by Steinbauer and Grigsby (30) with a combination of 0.2 percent KNO_3, an eight hour photo period, and a 5°C prechill for one week. If any one of these conditions was altered, the seeds remained dormant.

These authors felt that no primary dormancy was present in Plantago aristata or lanceolota since no cold pretreatment was necessary and only light and KNO_3 were needed to give complete germination. Delouche (12), however, felt that the special treatments of light and KNO_3 constituted dormancy since their requirement for germination decreased with time.

Lang (20) has reported the breaking of dormancy in tree buds and promoting germination in certain varieties of seed with gibberellin.

Gibberellic acid can replace the necessity for red light for lettuce seed germination according to Wittiver and Bukovac (36). These authors (35) also report that treating freshly harvested dormant sorghum, sudangrass, and Johnsongrass seeds with 1/4 to 1/2 gram of gibberellin per 100 pounds of seed has increased germination and improved stands.

Pauli (24) reported laboratory treatment of grain sorghum and wheat with gibberellic acid gave a germination reading up to one third faster than normal germination, but this was not borne out in actual field plantings.

Delouche (12) found that 100-1000 ppm gibberellic acid applied as a moistening agent to bracted plantain seeds overcame dormancy,

increased germination, and extended the temperature range over which germination occurred. Gibberellin eliminated the need for light except at 10 ppm and 35°C. Five hundred ppm gave complete germination in three days. He suggested, however, that a simple substitution of gibberellin for light was not involved, since light applied in combination with low concentrations of gibberellin gave an effect beyond that of gibberellin alone.

Stored primary wild oat seeds exhibit natural dormancy three to four months. Dormancy in secondary wild oat seeds will persist somewhat longer, according to Helgeson and Green (16).

By moistening the substrata with 50 ppm gibberellin, Helgeson and Green (16) obtained 88 percent germination for wild oats as compared to 8 percent germination for the water moistened control. Helgeson and Green (17) hypothesized that dormancy of wild oat seed was a physiological phenomenon related to the availability of a substance required for germination and that it was produced by the seed. Moistening the substrata with water extracts of 5 day old seedlings, they obtained a germination increase that was highly significant. The effectiveness of the extract appears to be proportional to the number of seedlings used per milliliter of the extract.

Ballard (4) broke the dormancy of Subterranian clover by treating the inhibited seeds with 0.5-5 percent CO_2 gas, placing activated carbon on the seeds, and by sealing the germination containers to collect and increase the CO_2 concentration from the

few respiring non-dormant seeds. Concentrations of CO_2 gas above 5 percent were found to be inhibiting to germination.

It was Ballard's opinion that the activated carbon did not absorb or destroy an inhibitory substance, as is usually the case, but instead he theorized that the activated carbon must have produced CO_2.

Barton and Salt (5) report inhibiting substances to be widely distributed in plant fruits and seeds. According to Toole, Hendricks, Borthwick, and Toole (32) germination inhibitors have been found in practically all of the structures that act as coverings of the seed or as coverings of the embryo within the seed. These inhibitors can be classified chemically into three main groups; namely, essential oils, alkaloids, and glucosides. Barton and Salt (5) and Toole (31) indicate that these inhibitors act, in one way or another, to block some step in the biological process of germination.

Hanson and Howell (15) have recently purified a germination inhibitor from immature soybean seed. It was found that the amount of inhibitor in the seed increases rapidly until seed dry weight reaches about 40mg per seed; it then remains practically constant until the seed begins ripening, after which it decreases rapidly to a low level at maturity which has no effect on the germination of the seed.

Axelrod and Shenberger (3) have isolated and partially purified inhibitors from apple and celery seeds and have indicated that they are proteinase in nature.

Carlson and Atkins (9) and Kantor (18) reported freezing temperatures in the fall will reduce the viability of high moisture sorghum seed. The moisture content and temperature at which initial injury occurred varied for different varieties. At 26°F and 25 percent moisture, reduction in viability varied from 0 to 50 percent. For some varieties the critical moisture percentage was as high as 35 percent at 26°F.

Carlson and Atkins (9) found that sorghum grain containing 10-12 percent moisture was not reduced in viability by the freezing treatments. Kantor's (18) seedling emergence data indicated that seed having a moisture content of less than 20 percent was most ideal for threshing from the standpoint of maintaining seed viability.

Robbins and Porter (26) reported sorghum reached an initial stage of viability at 50-60 percent moisture and that freshly harvested seed was dormant. Dormancy was overcome by curing, pre-chilling, and continuing the germination test at an alternating 20-30°C temperature until all viable seeds had germinated.

The effect of different methods of curing at the time of harvest was also studied. Seed of seven varieties of grain sorghum collected September 28 all showed evidence of prolonged dormancy. Seeds cured by hanging the panicles in the laboratory germinated better than those which were threshed and cured in cloth sacks.

Goodsell (14) observed that dormant seeds imbibed water but did not germinate. He found that dormancy in grain sorghums could be broken by mechanical scarification or a hot water treatment of

short duration. Mechanical scarification was accomplished by chipping away a small portion of the seed coat. The hot water method used was a modified method used by Walhood in effectively breaking the dormancy of wild cotton. Sorghum seed was placed in a wire basked and submerged in water held at 70°C for 4 minutes, then dipped in cool tap water, dried, and germinated. The temperature for this method is very critical. Water temperature of 70°C is not injurious to the seed, but a temperature of 75°C caused some damage and a temperature of 80°C or above caused complete kill of the embryos.

Goodsell postulated that dormancy of grain sorghum was due to some inhibitory substance in the seed coat. He theorized that breaking the seed coat eliminated enough of the barrier to permit normal germination and that the hot water method either destroyed or altered the inhibitory substance so it no longer retarded germination.

Wier (34) reported that Johnsongrass germination was more rapid at an alternating 30-45°C temperature and that significantly fewer firm ungerminated seeds remained at the end of the germination period.

From a limited amount of seed of black amber sorghum supplied by the South Dakota Laboratory, Bass (6) found that drying the seed four days at 40°C gave higher germination than seeds planted without drying or moistened with 0.2 percent KNO_3. He suggested from this limited data that drying the seeds first may help overcome dormancy.

Stanway (27) believed, with certain limitations, that lower germination and unnecessary delay in germination often resulted from prechilling sorghum seed at the Missouri Seed Testing Laboratory.

Further work by Stanway (28) suggests that an alternating temperature of 20-35°C with no prechill is more favorable for maximum germination of sorghum seed than is 20-30°C. Tests show that an alternating 20-30°C temperature with no prechill will give germination readings that are highly significant over 20-30°C alternating temperatures with a prechill.

MATERIALS AND METHODS

In 1957 four certified sorghum varieties were planted at three locations to check dormancy in freshly harvested seed and to observe if varying climatic conditions had any effect on occurrence of dormancy. Two grain sorghum varieties, Norghum and Reliance, and two forage sorghum varieties, Rancher and 39-30-S, were planted at the Highmore, Menno, and Watertown experimental substations.

Harvests were made at three week intervals beginning September 11 and continued until the material in the field was buried in snow. Moisture samples were taken at each harvest. Harvesting was done by collecting heads at random from each variety. The heads of each variety were subdivided into three groups. One group was threshed immediately and tested for germination. Group two was placed in porous burlap drying sacks and placed in a crop dryer for four days at 102°F. The heads were then removed, threshed, and germinated. The panicles in the third group were hung in the laboratory, allowed to dry for one week, threshed, and germinated.

As each group was threshed it was tested according to official seed testing rules set forth by the Association of Official Seed Analysts. The rules for Sorghum vulgare Pers. prescribe planting sorghum between folded blotters soaked in tap water and germinating in an alternating[1] 20-30°C dark germinator for ten days. The rules

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[1]Hereafter alternating temperature will refer to 8 hours at the higher temperature and 16 hours at the lower temperature unless otherwise specified.

prescribe a 5°C prechill for five days for fresh and dormant seed before being placed in a 20-30°C germinator. Preliminary and final germination counts were taken at five and ten days respectively.

The seed from each variety and group was threshed with a small scale mechanical head thresher and germinated in two ways. One 2x100 seed replicate was placed directly in a 20-30°C alternating dark germinator as prescribed in the official rules. The other 2x100 seed replicate of each variety was prechilled at 5°C and germinated in the 20-30°C alternating dark germinator. Preliminary and final germination counts were taken at five and ten days respectively.

Germination tests were made again February 28, 1958, using the same germination treatments as before to see if dormancy still persisted. Another germination test was made September 13, 1958, but this time no prechill was used. Germination studies of the 1957 harvest were continued by planting the 1957 seed in the field to observe field emergence. Readings of Ceresan[2] treated and untreated seeds of each variety and group were taken in the field emergence study.

Plantings were made at Brookings and Watertown in 1958. Preliminary data showed no effect of different climatic conditions on dormancy, but the Watertown planting was included here to complete this study because no data was available from this station in 1957. The same

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[2]DuPont Ceresan - active ingredient 5 percent Ethyl Mercury Phosphate.

varieties were used; in addition Dual, a grain sorghum, was included in the 1958 plantings.

Harvests were made at three week intervals commencing September 15. Each harvest was divided into three groups, fresh, dryer, and air dry, according to the method used for curing, and then tested with and without a prechill. In addition, another group was placed in a cold chamber at 3°F for 12-14 hours before testing.

The forage sorghums from the different curing groups that appeared dormant were subjected to various treatments in an effort to find a suitable method that would overcome dormancy. The outer glumes of the seed were removed on one blotter of each 2x100 replicate. Glumes were left intact as a check on the other. The blotters were then placed in the germinator for an additional five days, removed, and any additional germination recorded.

A series of treatments were set up for the first three harvests of dormant Rancher and 39-30-S forage sorghums. Two dry heat oven treatments were used. One treatment consisted of placing the seed in paper Seed Laboratory envelopes and placing them in an oven held at 40°C four days. Conditions for the other treatment remained the same except that the temperature was raised to 50°C.

Two hot water treatments were used. The seed was placed in perforated metal tea containers and emersed in hot water held at 75°C and 70°C respectively for four minutes. The containers were removed

and dipped in cool tap water; the seeds were spread out, allowed to dry, and tested for germination.

Seed was also presoaked three days in tap water at room temperature, the water decanted off, and the seed tested immediately for germination.

The 1958 data showed no effect of climatic conditions on dormancy at the Watertown station; therefore, 1959 plantings were made only at the Brookings station.

Some seed companies in South Dakota indicated to the South Dakota Seed Laboratory that they experienced some germination difficulty with RS 501, a grain sorghum, in the fall of 1958; therefore, this variety was used along with Norghum, Reliance, Rancher, and 39-30-S in the 1959 planting. Harvests were made at three week intervals commencing September 14. Each harvest was divided into three groups, fresh, dryer, and air dry and germinated with and without a prechill. Blotters containing dormant Rancher and 39-30-S forage sorghums from the first three harvests were placed back in the germinator for an additional five days and germination was recorded.

Using 2x100 seed replicates, germination tests were made on the first two harvests of the forage sorghums exhibiting dormancy. Seeds were planted between blotters soaked in tap water and germinated with and without a 5 day prechill under the following conditions: (1) constant 30°C, (2) constant 20°C, (3) alternating 15-30°C, and (4) alternating 20-30°C and 0.2 percent KNO_3 as the moistening agent.

Rancher and 39-30-S forage sorghums from the first three harvests were also treated with varying concentrations of gibberellic acid. Seeds were planted on folded blotters soaked in gibberellic acid solutions and placed in an alternating 20-30°C germinator. Concentrations used were 1000, 500, 250, 125, 62.5, 31.75, 15.88, and 7.94 milligrams per liter.

Rancher and 39-30-S forage sorghums from the October 27 harvest were planted on folded blotters soaked in KNO_3 solutions of 0.1, 0.2, 0.4, 1.0, 2.0, and 4.0 percent and placed in an alternating 20-30°C germinator.

Samples exhibiting dormancy of the September 27, November 3, and November 20 harvests were treated in two ways with concentrations of 1.0, 2.0, and 4.0 percent KNO_3. Seeds were soaked for 24 hours in the KNO_3 solutions, planted on blotters soaked in tap water, and germinated. Seeds for the other treatment were placed between folded blotters soaked in the KNO_3 solutions for 24 hours, then removed and planted between blotters soaked in tap water, and germinated.

Three different samples of Rancher and 39-30-S forage sorghums exhibiting dormancy from the November 3 and November 20 harvests were planted between blotters and suspended on glass rods in an aluminum cake pan. Each day these samples were placed in a 45°C oven for two, four, and eight hours respectively. To cut down on evaporation, covers were placed on each pan before being placed in the oven. When each pan was removed from the oven, the cover was removed; and the sample was placed in a 30°C germinator for the remainder of each day.

Rancher and 39-30-S forage sorghums from the November 27 harvest were treated in various ways. The series of treatments used were as follows: (1) glumes were pricked with a pin and a chip was removed from the seed coat adjacent to the germ, (2) a chip was removed from the seed coat on the tip of the seed, (3) the outer glumes were removed exposing the entire seed, (4) glumes were removed and a chip removed from the seed coat at the tip of the seed, and (5) glumes were removed and a chip removed from the seed coat adjacent to the germ. Each sample was then germinated in an alternating 20-30°C germinator.

Respiration of Rancher and 39-30-S forage sorghums that were artificially dried in the crop dryer from the November 20 harvest was studied. Seed harvested for the fresh and air dry studies of the October 6 harvest was used as the nondormant check. Tests were conducted with and without the outer glumes removed. Removal of the glumes was accomplished with the aid of a mechanical scarifier.

One hundred grams of seed for each sample were placed between paper germination towels and allowed to absorb water for 24 hours. The seed was then placed in the respiration chamber, and the test conducted. The apparatus used was a slightly modified form of the "gas stream method" as described by Loomis and Shull (23). The principal involves absorption of the CO_2 liberated in a solution of 0.1N Barium hydroxide and then titrating the residual $Ba(OH)_2$ with 0.1N Hydrochloric acid. The amount of CO_2 liberated = V x N x 22.0 where V is the difference between blank and experimental titration in milliliters, N is the normality of acid used for titration, and

22.0 is the normal weight of CO_2.

Dormancy in previous years was not pronounced in the grain sorghums used for this study; therefore, only the forage sorghums, Rancher and 39-30-S, were planted at the Brookings station in 1960. Harvests were initiated and continued at three week intervals commencing September 12. Tests were made primarily to substantiate findings of previous years.

Further testing in 1960 was done only for the December harvest that was dried artificially in the crop dryer. All tests used were identical to those used in 1959 for (1) 30-45°C oven for two, four, and eight hours, (2) the gibberellic acid series, (3) KNO_3 solutions and blotters series, (4) removing a chip from the seed coat at the tip of the kernel, and (5) removing the glumes.

Germination percentages were converted to corresponding angles by the formula Angle=arc $\sin\sqrt{\text{percentage}}$.

The conversion table in Statistical Methods by Snedecor (29) was used in converting percentages to angles. The angles were used in Duncan's (22) Multiple Range Test to analyse the data statistically.

EXPERIMENTAL RESULTS

Preliminary data in 1957 showed dormancy was present in some harvests of Rancher and 39-30-S forage sorghums. Therefore, testing was continued in 1958, 1959, and 1960.

Forage Sorghum Germinations

Tables 1, 2, 3, and 4 show germination percentages of Rancher and 39-30-S forage sorghums at the time they were harvested and after several months storage in the laboratory. Both natural and induced dormancy are evident, but induced dormancy is evident only in samples dried in the crop dryer. High germination was obtained even when the moisture content at harvest was 45 percent.

Dormancy varied considerably in the years this study was conducted, but the pattern of dormancy for both varieties for any one year was essentially the same. Natural dormancy was observed for the September 11, 1957, harvest. Induced dormancy was observed for the December 2 and December 26 harvests. Dormancy, in both cases, had either dissipated or was decreasing at the time of the February 28, 1958, germination tests. The August 8, 1958, germinations show dormancy had completely dissipated by this time.

The 1958 data shows natural dormancy present to some extent at all harvests. The May 30, 1959, germinations of these harvests show that dormancy was decreasing with storage but that it had not fully dissipated.

The 1959 data again shows dormancy in all samples; but the dormancy was not as persistent, since all dormancy had dissipated by May 27, 1960.

The only dormancy noted in 1960 was that induced by the crop dryer for the December 9 harvest. This dormancy was not profound, however, since it had dissipated one month later.

Generally speaking when the sorghums used in this study were left in the field after November 1, considerable injury due to freezing temperatures occurred. This is shown in tables 1, 2, 3, 4, 19, 20, 21, and 22.

Freshly harvested seed subjected to a 3°F temperature for 12-14 hours greatly reduced the viability of this seed. The moisture content when harvested showed a marked effect on this as can be seen in tables 3, 4, 21, and 22.

Treatment of Dormant Forage Sorghums

The mean germination in Table 5 shows no beneficial effect of removing the outer glumes of dormant seed after the ten day germination period.

Table 6 gives the germination percentages of dormant Rancher and 39-30-S forage sorghums which were left an additional 30 days in a 20-30°C alternating germinator. There was no appreciable increase in germination after the 20th day in the germinator, but a 10 percent increase in germination was obtained between the normal (10 day) germination period and the 20th day in the germinator.

Table 1. Percent Germination of the Forage Sorghum Rancher Collected at the Menno and Highmore Stations in 1957 Showing Dates Harvested and Tested, Percent Moisture When Harvested, and Methods of Handling When Harvested With Each Method Tested With and Without a Prechill

Date harvest	Date test	Percent moisture at harvest	Menno						Percent moisture at harvest	Highmore					
			Handling method at harvest							Handling method at harvest					
			Fresh			Dryer			Air dry				Dryer			Air dry	
			No	PC[1]	PC[2]	No	PC	PC	No	PC	PC		No	PC	PC	No	PC	PC
9/11/57	9/12/57	25.75	56	87	94	96	98	99	36.11	42	73	49	95	87	86
9/30/57	10/1/57	15.92	93	94	99	98	99	97	24.51	86	93	87	87	99	96
10/21/57	10/22/57	21.08	98	99	95	98	91	94	20.15	97	95	96	99	98	99
11/12/57	11/13/57	17.42	98	98	97	99	98	98	16.84	97	99	91	91	98	99
12/2/57	12/3/57	15.70	97	97	45	35	98	98	18.95	87	91	45	40	89	90
12/26/57	12/27/57	15.80	98	99	35	19	98	97							
9/11/57	2/28/58		99	99	98	99	98	99		93	95	99	99	95	92
9/30/57	2/28/58		99	99	98	97	99	98		98	97	98	97	99	99
10/21/57	2/28/58		97	99	95	99	99	99		97	97	98	92	99	95
11/12/57	2/28/58		97	98	98	97	97	95		96	96	84	89	95	97
12/2/57	2/28/58		97	98	95	70	95	97		85	90	78	62	83	91
12/26/57	2/28/58		97	99	94	66	97	99							
9/11/57	9/13/58		98	98	99	99	98	98		--	--	99	98	96	99
9/30/57	9/13/58		99	98	98	99	98	99		98	99	92	97	98	99
10/21/57	9/13/58		99	99	98	99	99	98		96	99	98	97	97	98
11/12/57	9/13/58		99	98	97	93	98	96		98	92	86	87	99	98
12/2/57	9/13/58		99	99	99	96	97	99		87	88	83	80	88	91
12/26/57	9/13/58		98	99	99	96	99	97							

1. Indicates no prechill.
2. Indicates five day prechill at 5-10°C.

Table 2. Percent Germination of the Forage Sorghum 39-30-S Collected at the Menno and Highmore Stations in 1957 Showing Dates Harvested and Tested, Percent Moisture When Harvested, and Three Methods of Handling When Harvested With Each Method Tested With and Without a Prechill

			Menno							Highmore						
		Percent moisture at harvest	Handling method at harvest						Percent moisture at harvest	Handling method at harvest						
			Fresh			Dryer			Air dry			Fresh			Dryer			Air dry	
Date harvest	Date test		No	PC[1]	PC[2]	No	PC	PC	No	PC	PC		No	PC	PC	No	PC	PC
9/11/57	9/12/57	23.07	46	78		80	98		98	99		38.61	26	67		75	82		60	66
9/30/57	10/1/57	15.87	99	99		99	99		99	99		27.88	96	85		94	90		97	91
10/21/57	10/22/57	18.40	99	99		96	98		97	99		22.25	94	97		95	96		98	98
11/12/57	11/13/57	17.47	98	98		99	98		97	97		16.27	88	87		76	86		93	92
12/2/57	12/3/57	15.76	99	99		42	37		97	95		18.30	67	53		53	49		81	85
12/26/57	12/27/57	15.22	95	98		46	25		99	99										
9/11/57	2/28/58		99	98		99	99		99	99			96	98		98	96		94	83
9/30/57	2/28/58		99	99		98	96		99	98			96	97		98	96		96	97
10/4/57	2/28/58		99	99		97	96		98	97			97	96		99	99		97	99
11/12/57	2/28/58		96	98		97	97		93	94			82	86		80	79		83	86
12/2/57	2/28/58		98	98		91	77		93	99			53	61		64	68		77	85
12/26/57	2/28/58		99	98		78	69		99	98										
9/11/57	8/13/58		98	99		99	99		98	100			97	99		97	98		90	97
9/30/57	8/13/58		99	99		99	99		99	100			99	97		98	96		98	96
10/21/57	8/13/58		99	98		97	98		98	98			97	99		99	99		99	99
11/12/57	8/13/58		98	95		96	98		95	91			84	86		86	83		88	87
12/2/57	8/13/58		99	99		98	90		98	98			59	52		83	77		79	93
12/26/57	8/13/58		99	96		98	93		98	95										

1. Indicates no prechill.
2. Indicates five day prechill at 5-10°C.

Table 3. Percent Germination of the Forage Sorghum Rancher Collected at the Brookings and Watertown Stations in 1958, 1959, and 1960 Showing Dates Harvested and Tested, Percent Moisture When Harvested, and Methods of Handling When Harvested With Each Method Tested With and Without a Prechill

Date harvest	Date tested	Percent moisture at harvest	Handling method at harvest: Fresh			Dryer			Air dry			Freezer		
			No	PC	PC	No	PC	PC	No	PC	PC	No	PC	PC
							Brookings							
9/15/58	9/16/58	44.33	91	80	60	94	51		38	16		16		
10/6/58	10/7/58	22.70	53	62	56	80	74		86	61		56		
10/28/58	10/29/58	15.90	88	87	87	85	73		80	58		56		
12/26/58	12/26/58		51	51	51	26	32		21	--		--		
9/15/58	5/30/59		95		91		87							
10/6/58	5/30/59		74		83		78							
10/28/58	5/30/59		91		81		79							
10/26/58	5/30/59		48		31		25							
							Watertown							
9/15/58	9/16/58	45.83	70	67	57	87	35		33	0		0		
10/6/58	10/7/58	20.50	51	64	76	91	82		99	30		57		
10/28/58	10/29/58	17.64	88	76	71	93	62		98	83		55		
9/15/58	5/30/59		83		88		92							
10/6/58	5/30/59		89		95		89							
10/28/58	5/30/59		97		92		85							
							Brookings							
9/14/59	9/15/59	19.09	96	48	67	67	56		69					
10/6/59	10/7/59	13.15	91	79	16	46	79		67					
10/27/59	10/28/59	16.25	39	77	26	64	63		82					
11/20/59	11/21/59		91	74	71	89	68		87					
9/14/59	5/27/60		99		98		100							
10/6/59	5/27/60		99		99		98							
10/27/59	5/27/60		98		99		97							
11/20/59	5/27/60		90											
							Brookings							
9/12/60	9/13/60	35.48	98	92	97	96	100		100					
10/4/60	10/5/60	26.80	100	100	100	99	99		99					
10/25/60	10/26/60	12.40	100	100	100	99	99		97					
11/17/60	11/18/60	17.00	98	100	98	96	98		99					
12/9/60	12/10/60	18.00	100	96	73	67	97		95					
9/12/60	4/11/60		100		100		100							
10/4/60	4/11/60		99		99		99							
10/25/60	4/11/60		99		97		99							
11/17/60	4/11/60		99		96		96							
12/9/60	4/11/60		96		98		96							

Table 4. Percent Germination of the Forage Sorghum 39-30-S Collected at the Brookings and Watertown Stations in 1958, 1959, and 1960 Showing Dates Harvested and Tested, Percent Moisture When Harvested, and Methods of Handling When Harvested With Each Method Tested With and Without a Prechill

Date harvest	Date tested	Percent moisture at harvest	Handling method at harvest: Fresh No	Fresh PC	Fresh PC	Dryer No	Dryer PC	Dryer PC	Air dry No	Air dry PC	Air dry PC	Freezer No	Freezer PC	Freezer PC
							Brookings							
9/15/58	9/16/58	44.33	78	82		19	72		48	53		50	37	
10/6/58	10/7/58	22.70	55	52		61	73		72	71		68	75	
10/28/58	10/29/58	15.90	48	46		57	68		51	58		69	45	
12/26/58	12/26/58		47	38		32	23		44	28		--	--	
9/15/58	5/30/59		94			92			96					
10/6/58	5/30/59		73			72			67					
10/28/58	5/30/59		65			70			69					
12/26/58	5/30/59		42			50			38					
							Watertown							
9/15/58	9/16/58	42.73	72	60		25	96		17	20		2	1	
10/6/58	10/7/58	17.50	47	57		80	91		82	89		33	42	
10/28/58	10/29/58	17.70	67	60		48	82		52	83		71	47	
9/15/58	5/30/59		87			75			94					
10/6/58	5/30/59		89			93			91					
10/28/58	5/30/59		93			91			71					
							Brookings							
9/14/59	9/15/59	17.42	80	46		51	60		60	45				
10/6/59	10/7/59	12.64	55	48		24	51		54	63				
10/27/59	10/28/59	16.17	33	73		25	50		51	75				
11/20/59	11/21/59		91	83		77	88		83	93				
9/14/59	5/27/60		100			99			99					
10/6/59	5/27/60		99			100			100					
10/28/59	5/27/60		98			98			98					
11/20/59	5/27/60		99			94			99					
							Brookings							
9/12/60	9/13/60	34.91	99	95		97	77		99	100				
10/4/60	10/5/60	26.00	98	100		100	100		99	100				
10/25/60	10/26/60	13.00	99	99		99	98		98	97				
11/17/60	11/18/60	16.40	99	100		99	99		97	97				
12/9/60	12/10/60	19.00	98	97		67	67		95	91				
9/12/60	4/11/60		100			99			100					
10/4/60	4/11/60		100			99			99					
10/25/60	4/11/60		99			99			98					
11/17/60	4/11/60		99			98			99					
12/9/60	4/11/60		96			97			96					

The mean germination of dormant Rancher and 39-30-S forage sorghums in Table 7 shows treatments for four days in an oven at 40°C and 50°C, submerged 4 minutes in water bath at 70°C and 75°C, and a three day presoak in tap water did not break dormancy in this seed. There was a slight increase in germination over the check for the four day oven treatment at 40°C and 50°C, but it was not statistically significant. Hot water treatments of 70°C and 75°C for four minutes, which were effective in breaking dormancy in grain sorghums for Goodsell (14), showed no effect in this study. Both hot water treatments and the three day presoak results are in disagreement with Goodsell's postulation that some water soluble inhibitor was present in the seed coat.

Table 8 gives the percent field emergence of Norghum and Reliance grain sorghums and Rancher and 39-30-S forage sorghums harvested in the fall of 1957. Much variation was observed in these grain sorghums in both treated and untreated subsamples. Germination of these forage sorghums was quite uniform in both treated and untreated subsamples and in the different methods of handling when the samples were harvested. Composite variety means for each variety tested from different stations, different dates of harvest, and different methods of handling at harvest indicate that when seed of comparable laboratory germination is planted these forage sorghums give significantly higher field stands than do the grain sorghums tested here. This could be due in part to the protection of the seed and embryo by the outer glumes and by the antibiotic effect of

Table 5. Total Germination of Rancher and 39-30-S Forage Sorghums Harvested at the Brookings and Watertown Stations in 1958. Ungerminated Seeds Were Given an Additional Five Days in the Germinator. After the Ten Day Germination Period, Glumes Were Removed From Seed on One Blotter of Each 2x100 Seed Replicate; Glumes Were Left Intact on the Other.

Date harvest and tested	Fresh No.[1]	Fresh PC[2]	Fresh PC		Dryer No	Dryer PC	Dryer PC		Air dry No	Air dry PC	Air dry PC		Freezer No	Freezer PC	Freezer PC	
	gl off	gl on	gl off	gl on	gl off	gl on	gl off	gl on	gl off	gl on	gl off	gl on	gl off	gl on	gl off	gl on
							Rancher, Brookings									
9/15/58	92	93	82	83	83	87	96	95	81	79	62	68	17	16	17	18
10/6/58	61	59	70	68	75	76	80	80	81	77	86	86	63	66	69	67
10/28/58	88	88	87	87	87	89	85	85	76	79	80	80	60	59	59	66
							Rancher, Watertown									
9/15/58	85	84	88	86	78	77	88	90	67	65	64	67	0	0	0	0
10/6/58	79	82	92	93	86	92	95	91	96	99	97	97	49	56	90	100
10/28/58	91	92	91	99	75	79	93	93	80	94	--	--	91	89	91	95
							39-30-S, Brookings									
9/15/58	83	82	88	86	83	87	96	95	83	76	74	80	50	50	48	49
10/6/58	61	70	63	70	71	70	73	73	78	75	73	73	76	77	82	89
10/28/58	54	49	48	62	62	62	68	68	60	65	58	58	72	73	49	50
							39-30-S, Watertown									
9/15/58	81	82	82	85	61	53	96	97	53	42	61	59	2	2	1	1
10/6/58	63	75	86	82	94	95	93	94	88	89	89	89	72	79	76	81
10/28/58	81	76	81	85	65	88	82	82	90	90	89	86	84	80	66	91
Mean	76	77	79	82	82	79	87	86	77	77	75	76	53	53	54	58

1. Glumes removed.
2. Glumes left intact.

Table 6. Percent Germination of the Forage Sorghums, Rancher and 39-30-S, Harvested at the Brookings Station in 1959. Dormant Seed From the First Germination Test Was Left on Blotters and Given an Additional 30 Days in an Alternating 20-30°C Germinator With Germination Counts Taken at Five Day Intervals

Dates harvest and test	Method of handling	Rancher Days in germinator							39-30-S Days in germinator						
		10	15	20	25	30	35	40	10	15	20	25	30	35	40
9/14/59	FR[1]-FR[2]	96	96	96	96	96	96	96	80	95	96	97	97	97	97
9/14/59	FR-PC	48	91	98	98	98	98	98	46	86	91	92	92	92	92
9/14/59	DR-FR	67	72	75	75	76	76	76	51	63	70	71	71	71	71
9/14/59	DR-PC	67	69	73	74	74	74	74	60	61	65	65	65	65	65
9/14/59	AD-FR	56	67	84	85	85	85	85	60	68	73	73	73	73	73
9/14/59	AD-PC	69	72	81	82	82	82	82	45	45	55	56	56	56	56
10/6/59	FR-FR	91	92	92	92	92	92	92	55	56	56	58	58	58	58
10/6/59	FR-PC	79	79	81	81	81	81	81	48	50	51	51	51	51	51
10/6/59	DR-FR	16	25	26	26	26	26	26	16	17	18	18	18	18	18
10/6/59	DR-PC	46	48	51	51	51	51	51	51	51	53	53	53	53	53
10/6/59	AD-FR	79	80	80	80	80	80	80	54	56	56	56	56	56	56
10/6/59	AD-PC	67	67	68	68	68	68	68	63	63	64	64	64	64	64
10/27/59	FR-FR	39	43	53	53	53	53	53	33	34	38	38	38	38	38
10/27/59	FR-PC	77	78	79	79	79	79	79	73	73	73	73	73	73	73
10/27/59	DR-FR	26	29	41	41	41	41	41	25	33	41	41	41	41	41
10/27/59	DR-PC	64	71	73	73	73	73	73	50	64	66	66	66	66	66
10/27/59	AD-FR	63	65	70	70	70	70	70	51	66	70	70	70	70	70
10/27/59	AD-PC	82	83	84	84	84	84	84	75	81	82	82	82	82	82
Mean		63	68	73	73	73	73	73	52	59	62	62	62	62	62

1. FR, DR and AD, column one, indicates fresh, dryer, and air dry.
2. FR and PC, column two, indicate no prechill and five day prechill at 5°C.

Table 7. November 12 Germination of Dormant Rancher and 39-30-S Forage Sorghums Harvested at the Brookings and Watertown Stations September 15, October 6, and October 28, 1958, After Pretreatments of 40°C Oven Four Days, 50°C Oven Four Days, Submerged in 75°C and 70°C Water Baths Four Minutes and a Three Day Presoak in Tap Water

Date harvest	Method of handling	Rancher Oven 40°C 4 days	Oven 50°C 4 days	Water 75°C 4 min.	Water 70°C 4 min.	Water Presoak 3 days	Check	39-30-S Oven 40°C 4 days	Oven 50°C 4 days	Water 75°C 4 min.	Water 70°C 4 min.	Water Presoak 3 days	Check
				Brookings						Brookings			
9/15/58	Fresh	98	96	94	91	94	96	96	88	95	95	92	95
10/6/58	Fresh	82	75	75	70	72	71	82	82	81	83	79	79
10/28/58	Fresh	88	88	86	87	83	83	56	62	51	56	52	57
9/15/58	Dryer	95	100	58	79	97	92	99	97	97	96	82	99
10/6/58	Dryer	83	77	76	84	74	77	77	71	67	73	76	82
10/28/58	Dryer	88	85	81	87	89	78	66	71	72	64	60	74
9/15/58	Air dry	96	96	93	87	94	93	98	94	92	95	95	94
10/6/58	Air dry	78	84	78	80	78	84	88	84	77	87	70	84
10/28/58	Air dry	87	80	79	71	71	80	74	74	73	68	56	74
				Watertown						Watertown			
9/15/58	Fresh	94	90	84	87	88	92	97	90	89	87	88	92
10/6/58	Fresh	97	96	93	93	91	95	97	91	92	82	91	91
10/28/58	Fresh	98	98	98	96	91	96	91	88	89	89	87	89
9/15/58	Dryer	99	94	94	91	98	98	95	87	87	87	88	95
10/6/58	Dryer	93	93	90	90	94	95	95	91	90	94	91	94
10/28/58	Dryer	97	95	91	88	78	95	88	79	87	77	74	90
9/15/58	Air dry	98	92	96	78	95	94	98	77	93	68	86	78
10/6/58	Air dry	97	99	93	96	93	98	89	85	89	85	85	93
10/28/58	Air dry	98	97	98	82	72	97	96	91	93	88	78	95
Mean		92.6	90.3	86.5	85.4	86.2	89.7	87.9	83.4	84.1	81.9	79.4	86.4

the outer glumes. The latter is especially evident for forage sorghum seeds planted with and without the outer glumes in the laboratory germinator. Barton and Salt (5) mention the effect of water insoluble inhibitors in Iris as being good antibiotic agents.

The figures in Table 9 show the effect of various KNO_3 solutions on the germination of dormant Rancher and 39-30-S forage sorghums. It is quite evident that the lower concentrations for solutions and the higher concentrations for blotters were effective in breaking dormancy. Some injury was noted at the higher concentrations for solutions.

The analysis of variance for the figures in Table 9 is presented in Table 10. The 1960 means for solutions show significance at the .01 level for 0.4, 0.2, 0.1, and 1.0 percent KNO_3. The 1959 solution means showed significance at the .01 level for 1.0 percent KNO_3 and at the .05 level for 2.0 percent KNO_3.

The 1960 means for the blotters treatment show significance at the .01 level for 4.0 percent KNO_3 and significance at the .05 level for 2.0, 1.0, and 0.1 percent KNO_3. The 1959 means show significance at the .01 level for 4.0, 2.0, and 1.0 percent KNO_3 treatments.

The figures in Table 11 show the percent germination of dormant Rancher and 39-30-S forage sorghum seed germinated on blotters soaked in various concentrations of gibberellic acid. Treatments had little effect over the check in 1959, but the 1960 data show a marked increase over the check for some treatments.

Table 8. Percent Field Emergence at the Brookings Station, July 5, 1958, of Norghum, Rancher, 39-30-S, and Reliance Sorghums Harvested at the Menno and Highmore Stations in 1957 Using Treated and Untreated Subsamples

Date harvest	Station, Variety	Handling method at harvest: Fresh UNTRT	Fresh TRT[1]	Dryer UNTRT	Dryer TRT	Air dry UNTRT	Air dry TRT	Variety means
11/27/57	Menno,	70	29	77	59	75	88	
12/2/57	Norghum	80	58	78	75	89	92	
12/26/57		88	78	66	90	77	69	
								58.1
11/12/57	Highmore,	51	56	41	55	33	40	
12/2/57	Norghum	4	8	34	38	16	20	
11/12/57	Menno,	94	87	86	90	96	99	
12/2/57	Rancher	93	98	99	92	90	97	
12/26/57		95	94	96	69	98	92	
								91.5
11/12/57	Highmore,	93	91	79	83	99	90	
12/2/57	Rancher	89	87	78	77	80	90	
11/12/57	Menno,	94	83	81	94	94	85	
12/2/57	39-30-S	82	99	96	92	92	97	
12/26/57		93	92	93	95	99	96	
								88.1
11/12/57	Highmore,	85	74	79	79	99	90	
12/2/57	39-30-S	50	42	78	77	80	90	
11/12/57	Menno,	58	67	43	72	62	70	
12/2/57	Reliance	68	82	82	78	23	81	
12/26/57		55	62	60	74	69	63	
								53.9
11/12/57	Highmore,	50	44	27	42	44	53	
12/2/57	Reliance	24	32	26	30	32	34	

Variety Means	Rancher	39-30-S	Norghum	Reliance
	91.5	88.1	58.1	53.9
Stat. sig.				

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Table 9. Percent Germination of Dormant Rancher and 39-30-S Forage Sorghums Harvested at the Brookings Station in 1959 and 1960 and Germinated on Blotters Soaked in Tap Water After 24 Hour Pretreatments of (1) Soaking the Seeds in KNO_3 Solutions and (2) Placing the Seeds on Blotters Soaked in KNO_3 Solutions of 0.1, 0.2, 0.4, 1.0, 2.0, and 4.0 Percent

Date harvest	Date tested	Method of handling	Solutions							Blotters						
			.1%	.2%	.4%	1%	2%	4%	Check	.1%	.2%	.4%	1%	2%	4%	Check
			Rancher										Rancher			
12/9/60	12/29/60	Dryer	96	97	96	95	88	86	71	88	88	83	93	95	95	71
			39-30-S										39-30-S			
12/9/60	12/29/60	Dryer	96	95	97	93	83	86	77	84	78	78	88	86	93	77
			Rancher										Rancher			
10/27/59	11/18/59	Dryer				97	99	90	81				84	96	93	72
11/3/59	11/18/59	Dryer				88	89	86	53				71	67	94	56
11/20/59	11/30/59	Fresh				83	80	58	81				99	99	98	84
11/20/59	11/30/59	Dryer				83	78	75	80				97	96	95	76
11/20/59	11/30/59	Air dry				86	80	56	88				97	98	94	84
			39-30-S										39-30-S			
10/27/59	11/18/59	Dryer				99	95	91	72				89	98	98	81
11/3/59	11/18/59	Dryer				95	88	83	56				84	86	99	53
11/20/59	11/30/59	Fresh				91	85	81	84				94	95	94	81
11/20/59	11/30/59	Dryer				83	77	60	76				96	96	94	80
11/20/59	11/30/59	Air dry				82	81	80	84				96	95	95	88

Table 10. Analysis of Variance of Germination Percentages of Dormant Rancher and 39-30-S Forage Sorghums Harvested in 1959 and 1960 and Germinated on Blotters Soaked in Tap Water After 24 Hour Pretreatments of (1) Soaking the Seeds in KNO_3 Solutions and (2) Placing the Seeds on Blotters Soaked in KNO_3 Solutions of 0.1, 0.2, 0.4, 1.0, 2.0, and 4.0 Percent

	Solutions						
KNO_3 concentrations	.4%	.2%	.1%	1%	4%	2%	Check
1960 means	96.5	96.0	96.0	94.0	86.0	85.0	74.0
Statistical significance at .01 level	———				———		

KNO_3 concentrations	1%	2%	4%	
1959 means	88.7	85.2	76.0	75.5
Statistical significance at .05 level	———		———	

	Blotters						
KNO_3 concentrations	4%	2%	1%	.1%	.2%	.4%	Check
1960 means	94.0	90.5	90.5	86.0	83.0	80.5	74.0
Statistical significance at .05 level	———	———		———			
		———		———			
				———	———		
					———	———	

KNO_3 concentrations	4%	2%	1%	Check
1959 means	95.4	92.6	90.7	75.5
Statistical significance at .01 level	———		———	

Table 11. Percent Germination of the 1959 Harvest of Rancher and 39-30-8 Forage Sorghums Tested October 14 and the 1960 Harvest Tested December 29 on Blotters Soaked in Solutions of 1000, 500, 250, 125, 62.5, 31.75, 15.88, and 7.94 Milligrams Per Liter of Gibberellic Acid

Date harvest	Method of handling	1000	500	250	125	62.5	31.75	15.88	7.94	Check
					Rancher					
9/14/59	Fresh	98	99	100	99	98	100	100	98	100
10/6/59	Fresh	99	86	73	63	64	63	47	44	99
10/27/59	Fresh	89	93	99	84	98	96	81	65	98
9/14/59	Dryer	99	99	100	96	98	98	95	98	100
10/6/59	Dryer	90	59	42	37	46	29	18	16	53
10/27/59	Dryer	81	81	87	70	83	78	34	26	80
9/14/59	Air dry	100	100	98	99	99	99	99	99	100
10/6/59	Air dry	99	94	83	81	84	77	75	73	99
10/27/59	Air dry	87	93	95	81	98	94	66	51	97
					39-30-S					
9/14/59	Fresh	100	98	97	95	97	97	98	98	99
10/6/59	Fresh	99	73	62	48	52	49	48	52	97
10/27/59	Fresh	83	91	85	72	85	87	59	57	80
9/14/59	Dryer	100	96	97	94	92	95	93	93	99
10/6/59	Dryer	89	57	32	39	35	23	30	23	66
10/27/59	Dryer	65	71	61	51	67	61	44	32	58
9/14/59	Air dry	100	98	94	92	95	98	89	91	99
10/6/59	Air dry	97	78	61	45	55	44	47	47	85
10/27/59	Air dry	80	86	87	68	88	81	59	58	98
					Rancher					
12/9/60	Dryer	96	99	93	98	94	94	88	85	71
					39-30-S					
12/9/60	Dryer	88	96	93	89	89	90	80	87	77

Table 12 gives the analysis of variance for the figures in Table 11. No significance is apparent for the 1959 means. Six of the 1960 means show significance over the check at the .01 level of comparison with the 500 milligram per liter treatment being the most effective in breaking dormancy. It should be mentioned here that only a limited amount of dormant seed was available for use in obtaining these results.

Table 13 gives the germination percentages of dormant Rancher and 39-30-S forage sorghums germinated on blotters soaked in various concentrations of KNO_3. Concentrations of KNO_3 above 0.4 percent markedly reduced germination. No beneficial effects for breaking dormancy were evident for the lower concentrations of KNO_3.

Induced dormancy was still present in the samples dried in a crop dryer. The 0.1 percent concentration of KNO_3 increased the germination of these samples over the check, but it did not completely overcome dormancy.

Table 14 gives the germination percentages of dormant Rancher and 39-30-S forage sorghum seed after various mechanical pretreatments of the seed coat and outer glumes. The means for all treatments show high significance at the .01 level of comparison.

Table 15 gives the percent germination and analysis of variance for dormant Rancher and 39-30-S sorghum seed tested with various combinations of temperature, prechill, and 0.2 percent KNO_3.

The means show three combinations that germinated better than the check, but only the 20-30°C temperature with 0.2 percent KNO_3

Table 12. Analysis of Variance of the Mean Germination Percentages of Dormant Rancher and 39-30-S Forage Sorghums Harvested at the Brookings Station in 1959 and 1960 and Germinated on Blotters Soaked in 1000, 500, 250, 125, 62.5, 31.75, 15.88, and 7.94 Milligrams Per Liter of Gibberellic Acid

Gib. acid conc.	1000	Check	500	250	62.5	31.75	125	15.88	7.94
1959 means	92.5	89.3	86.2	80.7	79.7	76.1	73.0	65.7	62.3
Stat. significance	None								

Gib. acid conc.	500	125	250	1000	31.75	62.5	7.94	15.88	Check
1960 means	97.5	93.5	93.0	92.5	92.0	91.5	86.0	84.0	74.0
Stat. significance at .01 level									

Table 13. November 4, 1959, Germination of Rancher and 39-30-S Forage Sorghums Harvested at the Brookings Station October 27, 1959, and Germinated on Blotters Soaked in Solutions of 0.1, 0.2, 0.4, 1.0, 2.0, and 4.0 Percent KNO_3

Method of handling	Percent KNO_3 concentrations						
	.1	.2	.4	1	2	4	Check
				Rancher			
Fresh	99	99	93	41	12	0	97
Dryer	73	22	16	3	1	0	49
Air dry	98	99	94	35	11	0	97
				39-30-S			
Fresh	99	97	88	55	22	1	95
Dryer	75	47	30	12	6	0	47
Air dry	99	98	94	42	13	0	96

Statistical significance None

Table 14. November 24, 1959, Germination and Analysis of Variance of Rancher and 39-30-S Forage Sorghums Harvested at the Brookings Station November 20, 1959, After Pretreatments Where Glumes Were Pricked and a Chip Removed From the Side of the Seed Coat Adjacent to the Germ, a Chip Was Removed From the Tip of the Seed, Glumes Were Removed, Glumes Were Removed and Seed Coat Chipped at Tip of Seed, and Glumes Were Removed and Seed Coat Chipped Adjacent to the Germ

Method of handling	gl prick side chip	gl on tip chip	gl rem'd	gl rem'd tip chip	gl rem'd side chip	Check
			Rancher			
Fresh	92	94	92	96	92	57
Dryer	96	98	98	97	99	80
Air dry	97	98	95	97	96	88
			39-30-S			
Fresh	94	98	91	99	98	69
Dryer	92	96	96	97	97	88
Air dry	95	96	97	96	92	90

Treatments	gl rem'd tip chip	gl on tip chip	gl rem'd side chip	gl rem'd	gl prick side chip	Check
Means	97.0	96.7	95.7	94.8	94.3	78.9
Stat sig. at .01 level						

Table 15. Percent Germination of Rancher and 39-30-S Forage Sorghums Harvested at the Brookings Station in 1959 and Tested October 23 Both With and Without a Five Day Prechill at Constant 20°C, Alternating 15-30°C, Alternating 20-30°C and 0.2 Percent KNO_3

Date harvest	Method of handling	Constant 30°C	Constant 20°C	Constant 30°C PC-5	Constant 20°C PC-5	15-30°C	15-30°C PC-5	20-30°C 0.2% KNO_3	20-30°C 0.2% KNO_3 PC-5	Check
						Rancher				
9/14/59	Fresh	98	99	100	100	89	88	100	100	100
9/14/59	Dryer	98	99	99	97	83	85	99	100	99
9/14/59	Air dry	99	100	100	99	92	91	99	99	100
10/6/59	Fresh	90	67	99	85	85	74	100	99	99
10/6/59	Dryer	61	9	62	15	29	90	99	79	53
10/6/59	Air dry	85	73	96	83	90	88	100	100	100
						39-30-S				
9/14/59	Fresh	97	98	93	98	93	91	100	100	99
9/14/59	Dryer	93	95	98	97	87	95	100	100	99
9/14/59	Air dry	93	99	100	99	95	97	100	98	99
10/6.59	Fresh	62	59	100	79	78	84	100	99	97
10/6/59	Dryer	48	20	68	47	29	77	98	90	66
10/6/59	Air dry	65	58	91	77	98	98	100	99	85

Treatments	20-30°C 0.2% KNO_3	20-30°C 0.2% KNO_3 PC-5	Constant 30°C PC-5	Check	15-30°C PC-5	Constant 20°C PC-5	Constant 30°C	15-30°C	Constant 20°C
Means	99.6	96.9	92.2	91.3	88.2	81.3	82.4	79.0	73.0
Stat. sig. at .05 level									

show significance at .05 level of comparison.

Table 16 gives the percent germination of Rancher and 39-30-S forage sorghums harvested at the Brookings station in 1959 and 1960 and germinated at an alternating 30-45°C temperature.

The analysis of variance for the mean germinations of Table 16 is given in Table 17. The two and four hour treatments at 45°C showed significance at the .01 level for the 1959 means. The 1960 means showed significance for all treatments at the .05 level and were very close to being significant at the .01 level. The 1960 data again was for only a limited amount of dormant material.

Table 18 shows respiration comparison of dryer samples of dormant and nondormant Rancher forage sorghum harvested at the Brookings station in 1960. The analysis of variance shows a significant difference at the .05 level between respiration of dormant and nondormant seed. Also indicated here is the fact that the seeds respire more rapidly when the outer glumes are removed.

Grain Sorghum Germinations

The grain sorghum varieties were handled with the same initial handling procedures used for the forage sorghums. Tables 19, 20, 21, 22, and 23 give the germination percentages of Reliance, Norghum, Dual and RS 501 grain sorghums at the time they were harvested and after several months storage in the laboratory. Neither natural nor induced dormancy was evident in any samples for the years they were tested. One exception was the October 28, 1958, dryer sample of Dual.

Table 16. Percent Germination of Rancher and 39-30-S Forage Sorghums Harvested at the Brookings Station in 1959 and 1960 and Germinated at an Alternating Temperature of 30-45°C

Date harvest	Date tested	Method of handling	Hours in 45° oven*			
			2 hrs.	4 hrs.	8 hrs.	Check
				Rancher		
11/3/59	11/9/59	Dryer	100	100	90	83
11/20/59	11/30/59	Fresh	94	98	74	81
11/20/59	11/30/59	Dryer	95	98	88	80
11/20/59	11/30/59	Air dry	96	98	81	88
				39-30-S		
11/3/59	11/9/59	Dryer	100	98	95	79
11/20/59	11/30/59	Fresh	98	99	86	84
11/20/59	11/30/59	Dryer	97	92	84	76
11/20/59	11/30/59	Air dry	99	97	84	84
				Rancher		
12/9/60	12/29-60	Dryer	97	98	95	71
				39-30-S		
12/9/60	12/29/60	Dryer	97	92	93	77

*Hours denote time samples were in 45°C oven each day of the germination period.

Table 17. Analysis of Variance of the Mean Germination Percentages of Dormant Rancher and 39-30-S Forage Sorghums Harvested at the Brookings Station in 1959 and 1960 and Germinated at an Alternating Temperature of 30-45°C

Hours in 45°C oven	4 hrs.	2 hrs.	8 hrs.	Check
1959 means	97.5	97.4	85.3	81.9
Statistical significance at .01 level	———	———	———	

Hours in 45°C oven	2 hrs.	4 hrs.	8 hrs.	Check
1960 means	97	95	94	74
Statistical significance at .05 level	———	———	———	

Table 18. Respiration of Dormant and Nondormant Samples of Rancher Forage Sorghum Harvested at the Brookings Station in 1960 Using Samples That Had Been in the Crop Dryer. Respiration is given as Milligrams of CO_2 Evolved and Was Checked With and Without the Outer Glumes Removed

Date harvest	Date tested	Condition of glumes	Milligrams CO_2 evolved	
			Dormant	Nondormant[1]
11/3/60	11/15/60	Intact	8.33	9.31
11/3/60	11/15/60	Removed	8.98	10.96
11/3/60	11/15/60	Removed	10.52	12.38
Means			9.28*	10.88

1. Nondormant samples from Dryer of October 6 harvest.
* Significant at 5% level of comparison.

Table 19. Percent Germination of the Grain Sorghum Reliance Collected at the Menno and Highmore Stations in 1957 Showing Dates Harvested and Tested, Percent Moisture When Harvested, and Methods of Handling When Harvested With Each Method Tested With and Without a Prechill

Date harvest	Date tested	Percent moisture at harvest	Handling method at harvest: Fresh No	Fresh PC	Fresh PC	Dryer No	Dryer PC	Dryer PC	Air dry No	Air dry PC	Air dry PC
						Menno					
9/11/57	9/12/57	27.05		97	95		97	97		93	96
9/30/57	10/1/57	15.92		96	99		98	99		99	99
10/21/57	10/22/57	18.60		97	98		99	97		99	97
11/12/57	11/13/57	17.42		95	95		96	95		98	98
12/2/57	12/3/57	16.29		95	97		96	92		95	97
12/26/57	12/27/57	16.11		93	90		92	90		93	90
9/11/57	2/28/58			95	98		93	98		92	93
9/30/57	2/28/58			98	98		96	96		97	92
10/21/57	2/28/58			95	87		97	97		95	97
11/12/57	2/28/58			91	95		81	83		84	89
12/2/57	2/28/58			96	94		95	94		93	91
12/26/57	2/28/58			88	86		88	94		87	84
9/11/57	8/19/58						98	99		97	96
9/30/57	8/19/58			98	97		96	96		96	93
10/21/57	8/19/58			93	92		93	97		96	96
11/12/57	8/19/58			96	88		91	84		97	93
12/2/57	8/19/58			96	86		97	90		96	91
12/26/57	8/19/58			92	83		94	90		91	81
						Highmore					
9/11/57	9/12/57	37.34		85	87		96	97		98	97
9/30/57	10/1/57	23.98		95	92		97	98		98	96
10/21/57	10/22/57	19.79		95	93		97	98		95	98
11/12/57	11/13/57	17.61		69	66		55	55		74	73
12/2/57	12/3/57	20.65		31	35		44	44		33	31
9/11/57	2/28/58			88	92		95	95		97	98
9/30/57	2/28/58			92	84		94	96		90	93
10/21/57	2/28/58			90	88		95	88		97	95
11/12/57	2/28/58			61	55		45	44		53	56
12/2/57	2/28/58			39	25		35	47		26	36
9/11/57	8/19/58						99	91		98	98
9/30/57	8/19/58			90	84		97	92		91	86
10/21/57	8/19/58			96	85		94	90		92	92
11/12/57	8/19/58			61	64		55	44		60	59
12/2/57	8/19/58			39	30		50	35		31	33

Table 20. Percent Germination of the Grain Sorghum Norghum Collected at the Menno and Highmore Stations in 1957 Showing Dates Harvested and Tested, Percent Moisture When Harvested, and Methods of Handling When Harvested With Each Method Tested With and Without a Prechill

Date harvest	Date tested	Percent moisture at harvest	Handling method at harvest: Fresh		Dryer		Air dry	
			No PC	PC	No PC	PC	No PC	PC
					Menno			
9/11/57	9/12/57	27.05	93	95	97	96	95	96
9/30/57	10/1/57	15.92	98	96	97	97	96	96
10/21/57	10/22/57	18.60	96	98	98	97	94	97
11/12/57	11/13/57	17.42	96	95	97	96	97	96
12/2/57	12/3/57	16.29	98	98	97	90	98	96
12/26/57	12/27/57	16.11	88	91	90	88	96	95
9/11/57	2/28/58		98	98	95	97	88	92
9/30/57	2/28/58		98	97	95	96	94	93
10/21/57	2/28/58		90	91	99	97	90	90
11/12/57	2/28/58		88	92	70	84	75	84
12/2/57	2/28/58		92	95	88	97	93	96
12/26/57	2/28/58		84	86	92	95	91	93
9/11/57	9/13/58		97	96	99	94	95	95
9/30/57	9/13/58		99	97	98	97	96	93
10/21/57	9/13/58		96	91	98	97	96	93
11/12/57	9/13/58		94	90	97	86	95	87
12/2/57	9/13/58		96	90	98	87	97	95
12/26/57	9/13/58		89	83	97	88	95	86
					Highmore			
9/11/57	9/12/57	35.66	93	90	98	98	97	98
9/30/57	10/1/57	30.51	95	95	98	97	99	98
10/21/57	10/22/57	23.42	94	95	96	97	97	99
11/12/57	11/13/57	17.09	68	61	68	74	57	57
12/2/57	12/3/57	18.08	12	16	54	54	12	16
9/11/57	2/28/58		90	89	98	95	97	97
9/30/57	2/28/58		90	92	95	96	97	46
10/21/57	2/28/58		89	85	92	94	95	96
11/12/57	2/28/58		56	60	59	63	45	45
12/2/57	2/28/58		8	9	43	43	28	21
9/11/57	8/19/58		--	--	97	97	98	98
9/30/57	8/19/58		93	92	96	96	95	95
10/21/57	8/19/58		90	84	96	96	98	96
11/12/57	8/19/58		56	46	71	58	53	54
12/2/57	8/19/58		8	9	52	46	27	26

Table 21. Percent Germination of the Grain Sorghums, Reliance and Norghum, Harvested at the Brookings and Watertown Stations in 1958 Showing Dates Harvested and Tested, Percent Moisture When Harvested, and Methods of Handling When Harvested With Each Method Tested With and Without a Prechill

Date harvest	Date tested	Percent moisture at harvest	Handling method at harvest: Fresh No	Fresh PC	Fresh PC	Dryer No	Dryer PC	Dryer PC	Air dry No	Air dry PC	Air dry PC	Freezer No	Freezer PC	Freezer PC
						Reliance, Brookings								
9/15/58	9/16/58	39.25	83	71		97	97		97	95		7	11	
10/6/58	10/7/58	13.95	93	86		96	86		96	84		94	78	
10/28/58	10/29/58	15.60	75	74		94	93		97	91		95	88	
12/26/58	12/27/58		12	12		26	8		3	3		--	--	
9/15/58	5/30/59		71			97			97					
10/6/58	5/30/59		92			97			97					
10/28/58	5/30/59		65			97			99					
12/26/58	5/30/59		15			3			25					
						Reliance, Watertown								
9/15/58	9/16/58	42.53	71	50		93	95		98	97		1	3	
10/6/58	10/7/58	17.30	96	94		96	92		95	93		88	90	
10/28/58	10/29/58	17.38	89	89		86	84		69	72		86	96	
9/15/58	5/30/59		66			98			99					
10/6/58	5/30/59		93			94			95					
10/28/58	5/30/59		87			82			88					
						Norghum, Brookings								
9/15/58	9/16/58	43.52	61	45		94	89		98	97		3	8	
10/6/58	10/7/58	16.40	91	85		92	82		92	90		96	90	
10/28/58	10/29/58	16.97	96	92		82	76		83	82		86	87	
12/26/58	12/27/58		36	31		19	6		33	12		--	--	
9/15/58	5/30/59		58			95			96					
10/6/58	5/30/59		90			93			95					
10/28/58	5/30/59		95			85			87					
12/26/58	5/30/59		38			33			18					
						Norghum, Watertown								
9/15/58	9/16/58	44.95	70	57		81	71		96	92		1	2	
10/6/58	10/7/58	14.10	88	85		91	92		79	79		87	95	
10/28/58	10/29/58	20.05	90	84		92	94		89	73		89	83	
9/15/58	5/30/59		59			93			85					
10/6/58	5/30/59		85			88			94					
10/28/58	5/30/59		86			84			91					

Table 22. Percent Germination of the Grain Sorghum Dual Collected at the Brookings and Watertown Stations in 1958 Showing Dates Harvested and Tested, Percent Moisture When Harvested, and Methods of Handling When Harvested With Each Method Tested With and Without a Prechill

Date harvest	Date tested	Percent moisture at harvest	Handling method at harvest: Fresh		Dryer		Air dry		Freezer	
			No PC	PC	No PC	PC	No PC	PC	No PC	PC
					Brookings					
9/15/58	9/16/58	41.43	75	61	59	88	96	96	2	3
10/6/58	10/7/58	14.50	94	90	85	86	92	90	96	96
10/28/58	10/29/58	16.46	95	94	72	76	93	94	88	95
12/26/58	12/26/58		44	30	29	3	32	10	--	--
9/15/58	5/30/59		65		97		97			
10/6/58	5/30/59		96		90		94			
10/28/58	5/30/59		91		96		77			
12/26/58	5/30/59		34		30		18			
					Watertown					
9/15/58	9/16/58	44.33	77	68	75	85	97	95	1	1
10/6.58	10/7/58	11.86	93	90	91	86	94	93	94	94
10/28/58	10/29/58	17.32	93	90	86	81	88	80	92	89
9/15/58	5/30/59		66		96		94			
10/6/58	5/30/59		94		92		92			
10/28/58	5/30/59		86		84		91			

Table 23. Percent Germination of Norghum, Reliance, and RS 501 Grain Sorghums Harvested at the Brookings Station in 1959 Showing Dates Harvested and Tested, Percent Moisture When Harvested, and Methods of Handling When Harvested With Each Method Tested With and Without a Prechill

Date harvest	Date tested	Percent moisture at harvest	Handling method at harvest: Fresh		Dryer		Air dry	
			No PC	PC	No PC	PC	No PC	PC
					Norghum			
9/14/59	9/15/59	13.48	95	98	99	97	99	99
10/6/59	10/7/59	13.84	100	97	99	97	98	98
10/27/59	10/28/59	16.68	96	96	96	96	96	91
9/14/59	5/27/60		98		96		98	
10/6/59	5/27/60		99		98		98	
10/27/59	5/27/60		93		92		94	
					Reliance			
9/14/59	9/15/59	16.95	94	96	97	98	99	99
10/6/59	10/7/59	13.82	99	98	97	84	96	94
10/27/59	10/28/59	18.70	90	94	95	84	95	92
9/14/59	5/27/60		97		97		99	
10/6/59	5/27/60		99		95		97	
10/27/59	5/27/60		95		91		90	
					RS 501			
9/14/59	9/15/59	23.61	96	97	95	98	96	98
10/6/59	10/7/59		97	95	88	95	97	98
10/27/59	10/28/59		89	96	93	93	96	95
9/14/59	5/27/60		95		97		97	
10/6/59	5/27/60		96		97		97	
10/27/59	5/27/60		96		89		93	

The germination of this sample was in the middle 70's at harvest time but showed a 96 germination when tested May 30, 1959.

The failure of the September 15, 1958, fresh harvest to reach its maximum germination or hold its initial germination for any period of time is quite evident in Tables 21 and 22. There is an indication here that Norghum, Reliance, and Dual grain sorghums with a moisture content above 37.5 percent are not readily germinable until the seed has first been dried to a point below this percentage. Also, the high moisture at this harvest could be the reason for the rapid deterioration of the germination below the initial germination when first harvested.

DISCUSSION

This study was undertaken with two purposes in mind. The first was to determine if dormancy was present in the grain sorghums, Norghum, Reliance, Dual and RS 501 and the forage sorghums, Rancher and 39-30-S. The second was to devise laboratory methods for breaking dormancy if dormancy was found to be present.

Data in the foregoing section indicated that both natural and induced dormancy exists in Rancher and 39-30-S forage sorghums and to a very limited extent in the grain sorghums, Norghum, Reliance, Dual, and RS 501. The special treatment of prechilling fresh and dormant seed at 5°C for five days as prescribed in the official rules of the Association of Official Seed Analysts did not break this dormancy.

Dormancy was observed in the forage sorghums, Rancher and 39-30-S, each year this study was conducted, but the occurrence and duration of the dormancy varied considerably from year to year. In most cases dormancy had dissipated by the normal sorghum planting time the following year.

The general results of this study add support to Stanway's (27) contention that samples not prechilled will give significantly higher germination readings than when all samples are subjected to a five day prechill.

Secondary or induced dormancy in some harvests was observed for the samples that were dried in a crop dryer. This was not anticipated, but knowing that induced dormancy may be present should help

considerably in answering some normally unexplainable germination questions that arise every year concerning sorghum germination in the laboratory. This may be especially evident during a wet fall when a considerable amount of the sorghum seed harvested is artificially dried.

Sorghum seed was found to retain high viability when harvested at moisture contents as high as 45 percent. Whether or not this is the peak for viability retention was not determined; but it would indicate that sorghums could be harvested early in the fall, artificially dried, and thus eliminate the hazard of damage by an early frost.

The effect of freezing temperatures on the germination of the sorghum varieties used in this study decreased as the moisture content of the seed decreased. However, the moisture content in relation to severity of viability reduction varied for the different varieties used.

Soaking dormant seeds in 0.4, 0.2, 0.1, and 1.0 percent KNO_3 solutions for 24 hours and then placing these seeds on blotters soaked in tap water gave maximum germinations that were highly significant. Other concentrations than those mentioned above showed a distinct increase in germination but were not statistically significant.

An alternating 30-45°C temperature in which dormant seeds were placed in a 45°C chamber for 2, 4, and 8 hours each day and then switched to a 30°C chamber for the remainder of each day gave

a highly significant increase in germination over the check. The two and four hour treatments in the 45°C chamber were equally effective. The eight hour treatment showed an increase in germination for the limited 1960 data, but injury to a few seedlings had occurred. Injury was thought to be due to scalding of the seedlings because of too long exposure at the 45°C temperature.

Although not shown in the tables it should be mentioned here that a few samples of Sorghum almum received at the laboratory were also tested at the 30-45°C temperature. In the few samples tested the two, four, and eight hour exposures to the 45°C temperature all showed progressively better germinations. The eight hour exposure gave increased germination readings of 25-35 percent.

A significant increase in germination at the .05 level was obtained when dormant seed was germinated at an alternating 20-30°C temperature with 0.2 percent KNO_3 used as a moistening agent. More experimental work should be done on this method before it could be used with any reliability as only three of the twelve samples tested showed marked dormancy at the time of testing. The dormancy in the others apparently had dissipated between the initial germination test and the October 23 germination test.

Based on a limited amount of dormant seed available for testing in 1960, the six highest concentrations of gibberellic acid showed a significant increase in germination. The validity of this is questionable when compared to the 1959 data in which no increase in germination was obtained for any of the concentrations used.

However, these data show indications similar to the finding of Wittiver and Bukovac (35), since they obtained increased germination of dormant sorghum, sudangrass, and Johnsongrass by treating with gibberellic acid. More work should be done along this line, however, to determine if gibberellic acid could be used as a reliable method to eliminate the dormancy barrier in the sorghums.

Mechanical scarification by chipping the seed coat gave highly significant increases in germination with and without the outer glumes removed. This would indicate that the outer glumes do not function to restrict gas exchange as in the case of western wheatgrass. It would also indicate that the seed coat, at least in part, may be the reason for dormancy. However, there still appears to be physiological dormancy as well since high germinations were obtained with a 30-45°C alternating temperature, KNO_3 treatment of solutions and blotters, and to a limited extent with gibberellic acid. These treatments would act more on the physiological rather than the mechanical cause of dormancy.

Although no data are presented here, extracts from young seedlings were taken and used as the moistening agent for some dormant samples. No increase in germination was obtained so apparently there is no growth promotor in the seedlings of sorghums similar to that found by Helgeson and Green (17) in wild oats.

Goodsell (14) found that chipping the seed coat or a hot water treatment for four minutes at 70°C would break dormancy in sorghum. From this he postulated that an inhibitor was present in the seed

coat and that the hot water treatment and chipping either destroyed or inactivated the inhibitor. Findings in this study are not in complete agreement with this theory, since no increase in germination was obtained for a four minute treatment in water at 70°C and 75°C or for a three day presoak in water at room temperature. Also, preliminary work of steeping complete seeds with outer glumes attached, outer glumes, fine hulls, brown pericarp threshings, brown seeds, and white endosperm for three days in water and using the solutions as moistening agents showed no effect of an inhibitor in any part. Therefore, it would seem that something besides mechanical restraint or a chemical inhibitor was the cause of dormancy.

It appears the outer glumes of the forage sorghums, Rancher and 39-30-S, are not the cause of dormancy. Removing the outer glumes of dormant seeds before germination tests were made and removal of glumes from dormant seed that had been in the germinator ten days gave no increase in germination except for the November 24, 1959, harvest. It should be mentioned here that glume removal before planting for some regular Seed Laboratory samples showed no beneficial effect whatsoever.

Respiration trials, though limited in number, show that dormant seeds respire less rapidly than nondormant seeds. Respiration increase was about equal for both dormant and nondormant seed when the outer glumes were removed. This would definitely indicate that dormancy in forage sorghums is physiological in nature.

Spring field planting of dormant samples harvested the previous fall showed no evidence of dormancy. In general the forage sorghums, Rancher and 39-30-S, gave much better stands than the grain sorghums, Norghum and Reliance, when seed of comparable germination was planted. This could be due in part to the protective and antibiotic effect of the outer glumes as was shown very vividly in laboratory tests where dormant and nondormant seeds of Rancher and 39-30-S with the outer glumes intact showed very little mold growth after the ten day germination period. In contrast, Rancher and 39-30-S with the outer glumes removed and Norghum, Reliance, Dual, and RS 501 all showed heavy mold infestations by the fourth day of the germination period. Seeds of Norghum and Reliance that did not produce seedlings showed no signs of dormancy at the time seedling counts were taken for all ungerminated seeds were rotted and decayed and showed no sign of life.

SUMMARY

Dormancy was found to be present in Rancher and 39-30-S forage sorghums and to a very limited extent in the grain sorghum Dual. Dormancy was observed each year this study was conducted in Rancher and 39-30-S, but the occurrence and duration varied considerably from year to year. The special treatment for fresh and dormant seed of prechilling at 5°C for five days as prescribed in the official rules of the Association of Official Seed Analysts did not break this dormancy.

Sorghum seed with 45 percent moisture at harvest time may retain high viability.

Drying freshly harvested seed in a crop dryer at 102°F induced dormancy in many cases. The duration and persistency of this induced dormancy was similar to that of the seeds that showed natural dormancy.

Dormant seeds soaked 24 hours in 0.4, 0.2, 0.1, and 1.0 percent KNO_3 and germinated on blotters soaked in tap water overcame dormancy. Similarly, dormant seeds placed between blotters soaked in 4.0, 2.0, and 1.0 percent KNO_3 solutions for 24 hours and germinated on blotters soaked in tap water overcame dormancy.

Two and four hour treatments per day at 45°C eliminated dormancy in the samples germinated at an alternating 30-45°C temperature.

Gibberellic acid and mechanical scarification by chipping the seed coat gave a limited indication that these methods may break dormancy, but more work along these lines would be necessary before they could be used with any degree of reliability.

The antibiotic effect of the outer glumes gives added protection to forage sorghum seeds; therefore, forage sorghums can be expected to give better field stands than grain sorghums when seed of comparable germination is planted. Sorghum varieties used in this study gave no indication of a water soluble chemical inhibitor in the outer glumes or various layers of the seed coat.

Nondormant samples respire more rapidly than dormant samples.

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